IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appln. No:	10/017,367
Applicant:	Kevin K. Lehmann et al.
Filed:	December 12, 2001
Title:	FIBER OPTIC BASED CAVITY RING-DOWN SPECTROSCOPY APPARATUS
TC/A.U.:	2877
Examiner:	Pham, Hoa Q.
Docket No.:	PRU-101US

DECLARATION UNDER 37 C.F.R. §1.132

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I, Peter B. Tarsa, hereby declare that:

1. I am currently employed by the Massachusetts Institute of Technology as a postdoctoral associate in the Biological Engineering Division. Previously, from 1999-2004, I was a doctoral candidate at Princeton University where, in that capacity, I was a co-inventor of various devices in the field of Cavity Ring-Down Spectroscopy.

2. Exhibit 1 is a copy of my *Curriculum Vitae* from which it can be seen that I have a Batchelor's degree in Chemistry, a Master's degree in Chemistry and a Ph.D. in Physical Chemistry.

3. I am a co-inventor of the invention which is the subject of this application.

4. I have reviewed the application and its prosecution history to date.

5. I understand that at present claims 1-8, 11-12, 14/11, 14/12, 17-49 and 52-56 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Stewart (Intra-Cavity and Ring-Down Cavity Absorption with Fibre Amplifier for Trace Gas Detection) in view of U.S.

Patent 5,168,156 to Fischer et al. I also understand that the remaining dependant claims stand rejected over various combinations of the Stewart and Fischer references.

6. In my opinion this combination of references does not result in our invention nor would one skilled in the art be lead to combine these references as suggest in the Office Action. My reasoning for this position is set forth in the following paragraphs.

7. The implementation of Cavity Ring-down Spectroscopy (CRDS) in an optical fiber resonator allows improved sensitivity in a versatile arrangement. Such sensitivity advantages are severely limited by the use of an architecture with high intrinsic round trip loss of the optical fiber resonator. Prior optical fiber sensor designs had high passive loss. In some designs, such loss was introduced by coupling light out and then back into the fiber on each round trip. This was done to allow for free space propagation of the light through an absorbing sample or a micro-gap sampling region, but such coupling introduces a minimum loss of tens of percent per round trip. In other designs, the resonator consists of a folded length of fiber, with feedback provided by a "tap" coupler. Such a configuration with this type of coupler produces net round trip loss of at least 50% per pass, limiting the potential for high sensitivity measurement. As such, resonators with such high loss are only moderately more sensitive than a single pass absorption configuration, which has the advantage of greater ease of use. Therefore, such high intrinsic loss designs have often included an active gain medium, such as a semiconductor laser gain region, fiber laser, or erbium doped optical amplifier. Such fiber sensors can be arranged either in a straight length or in a loop configuration with active regions in line. In principle, such amplifier devices can be carefully tuned to remove most of the intrinsic round trip loss of the resonator, allowing for light to propagate many round trips through the resonator and sample. This would appear to improve sensitivity. However, such a scheme requires active feedback control to prevent excessive gain fluctuations. Any such amplifying medium has intrinsic noise in its gain, which will be increased further, possibly dramatically, by instabilities in the pump system or in the feedback loop required to maintain steady round trip optical gain. The noise introduced into the measurement of the resonator decay time will diverge as the amplifier gain is tuned to just compensate for the intrinsic cavity loss. Optical saturation effects in the amplifier will introduce another source of instability, making the resonator decay rate a function of input optical power. Introduction of the above

sources of noise, which do not contribute to cavity ring-down spectroscopy in a passive resonator, substantially reduces the utility of such an approach.

8. To avoid these extraneous noise-inducing components, a passive optical fiber resonator composed of standard single mode fiber can be effectively used for CRDS sensing. The nature of such a device, which includes no active gain regions and has only an excitation source, signal detector, and un-driven fiber components, significantly improves signal stability. While the inclusion of gain regions will improve signal strength, the excessive noise caused by the additional required components offsets any benefits. In contrast, the absence of active components increases signal-to-noise response, and thus sensitivity, by several orders of magnitude and allows for simpler design and greater ease of use.

9. Although a fiber optic resonator can be constructed in a straight length configuration, the optimal design, and that of our claimed invention, is based on a closed fiber loop. A closed loop permits uninterrupted transmission of resonant radiation, thus avoiding the use of lossy reflective coatings that are required in a linear device or micro-gap sampling regions found in prior designs. Likewise, a resonator made by crossing a fiber with itself using a tap coupler to provide feedback will introduce high round trip loss. The minimization of system loss that is possible in a closed loop arrangement leads to increased resonator ring-down times and thus higher system sensitivity, further improving on the advantages of a passive device.

10. My review of the Stewart reference reveals that is neither a ring nor passive. On the contrary, Stewart requires that the fiber is of open ended construction and coupled to an amplifying portion (a non-passive element). Thus, Stewart lacks certain elements of the claimed invention.

11. Additionally, my review of the Fischer reference reveals at Column 4, lines 48 et seq. that a fiber loop not be used. Based on this, in my opinion others skilled in the art would not be motivated to combine Stewart and Fischer. Further, even if the teaching away of Fischer was ignored and the combination made, that combination would require the use of an non-passive fiber which is clearly different from the claimed invention.

12. By my signature below, I hereby declare that all statements made in this document of my own knowledge are true, and that all statements made on information and belief are believed to be true. Further, I hereby declare that these statements are made with the knowledge that willful false statements, and the like so made, are punishable by fine or imprisonment, or both, under Section 1001, Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing on the application.

Respectfully submitted,

Dated: 11/12/2004

Peter B. Tarsa

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EDUCATION

Princeton University — Princeton, NJ
Ph.D., Physical Chemistry, July 2004
Thesis title: *Optical Fiber Cavity Ring-down Spectroscopy*
Advisor: Kevin K. Lehmann
M.A., Chemistry, May 2001

Wake Forest University — Winston-Salem, NC
B.S. Chemistry, B.A. Physics, *cum laude*, May 1999

AWARDS AND HONORS

Coblentz Society Graduate Student Award, 2004

Society of Applied Spectroscopy, New York Section Graduate Student Award, 2004

RESEARCH EXPERIENCE

Postdoctoral Associate — 2004-present
Biological Engineering Division, Massachusetts Institute of Technology, Cambridge, MA
Advisor: Matthew J. Lang

Investigated effects of mechanical force on protein function through spectroscopic methods, including optical tweezers and single molecule fluorescence. Developed assays for single molecule studies, including immobilization and tethering of oligonucleotides and proteins.

Graduate Research Assistant — 1999-2004
Department of Chemistry, Princeton University, Princeton, NJ
Advisor: Kevin K. Lehmann

Designed and improved new methods for Cavity Ring-down Spectroscopy, including optical fiber and prism-based resonators. Explored surface chemistry modifications to enhance spectroscopic detection of biological species. Authored NSF grant proposal to fund fiber-optic spectroscopy research, which initiated product development and steps toward commercialization at collaborating firm, Tiger Optics, LLC. Proposed inventions and guided legal counsel in preparation of project-related patents.

Technical Consultant — 2002-2004
Tiger Optics, LLC, Warrington, PA

Collaborated with engineering and business teams for development and commercialization of research-related products. Advised Technical Review Board at annual meetings. Created research proposal for federal research funding of opto-electronic trace gas measurement device.

Undergraduate Research Assistant 1997-1999
Wake Forest University, Winston-Salem, NC
Researched high vacuum methods for investigating polycyclic aromatic hydrocarbons with quasi-linear Shpol-skii spectroscopy in the ultraviolet and visible regions.

Summer Research Laboratory Assistant 1997-1998
Ocean Spray Cranberries, Inc., Lakeville-Middleboro, MA
Integrated chromatographic and spectroscopic methods for quantitative analysis of ingredients and products. Assisted in method development for both High Performance Liquid Chromatography and Capillary Electrophoresis.

TEACHING EXPERIENCE

Princeton University Princeton, NJ
Assistant in Instruction
Experimental Chemistry I, Fall 2001
Trained other teaching assistants, supervised and evaluated undergraduates, and prepared experiments for integrated laboratory course.
Experimental Chemistry II, Spring 2000
Taught and evaluated students in integrated laboratory course.
Advanced General Chemistry, Fall 1999
Created and led weekly classroom discussion of General Chemistry topics.

Wake Forest University Winston-Salem, NC
Teaching Assistant
General Physics, Fall 1997
Graded weekly problem sets.

ACADEMIC OUTREACH

Treasurer, Princeton University Scholars in the Schools 2002-2004
Coordinated outreach program in Trenton public schools through the development of a $20,000 federal grant proposal and organization of 12 member graduate student team.

Class Representative, Princeton Chemistry Graduate Student Organization 2003-2004
Enhanced chemistry graduate student life through planning and organization of recruiting and social events.

PATENTS

Kevin K. Lehmann, Peter B. Tarsa. Paul Rabinowitz. "Fiber Optic Based Cavity Ring-Down Spectroscopy Apparatus," United States Patent Application # 20030107739, December 11, 2001.

Kevin K. Lehmann, Peter B. Tarsa, Paul Rabinowitz. "Method and Apparatus for Enhanced Evanescent Field Exposure in an Optical Fiber Resonator for Spectroscopic Detection and Measurement of Trace Species." United States Patent Application # 20030109055, May 29, 2002.

Kevin K. Lehmann, Peter B. Tarsa, Paul Rabinowitz. "Tapered Fiber Optic Strain Gauge Using Cavity Ring-down Spectroscopy." United States Patent Application # 20040118997, August 20, 2003.

PUBLICATIONS

John B. Dudek, Peter B. Tarsa, Armando Velasquez, Mark Wladyslawski, Paul Rabinowitz, Kevin K. Lehmann. "Trace moisture detection using continuous-wave cavity ring-down spectroscopy." *Analytical Chemistry*, **75** (17), 4599-4605, 2003.

Peter B. Tarsa, Paul Rabinowitz, Kevin K. Lehmann. "Evanescent field absorption in a passive optical fiber resonator using continuous-wave cavity ring-down spectroscopy." *Chemical Physics Letters*, **383** (3-4), 297-303, 2004.

Peter B. Tarsa, Diane M. Brzozowski, Paul Rabinowitz, Kevin K. Lehmann. "Cavity Ring-down Strain Gauge." *Optics Letters*, **29** (12), 1339-1341, 2004.

Peter B. Tarsa, Aislyn D. Wist, Paul Rabinowitz, Kevin K. Lehmann. "Single cell detection with cavity ring-down spectroscopy." *Applied Physics Letters*, **85** (19), 4523-4525, 2004.

PRESENTATIONS

Peter Tarsa, Paul Rabinowitz, Kevin Lehmann. "A Passive Optical Fiber Resonator for the Cavity Ringdown Detection and Measurement of Trace Species. Invited talk given at Tiger Optics, LLC Technical Review Board Meeting, March 2002.

Peter Tarsa, Kevin Lehmann, Paul Rabinowitz. "A Passive Optical Fiber Resonator for Cavity Ringdown Spectroscopy." Talk given at International Symposium on Molecular Spectroscopy, Columbus, OH, June 2002.

P.B. Tarsa, P. Rabinowitz, K.K. Lehmann. "Passive optical fiber resonator for cavity ringdown spectroscopy." Poster presentation at 224th American Chemical Society National Meeting in both Analytical Chemistry and Sci-Mix sessions, Boston, MA, August 2002.

Peter Tarsa, Paul Rabinowitz, Kevin Lehmann. "A Passive Optical Fiber Resonator for the Cavity Ringdown Detection and Measurement of Trace Species." Poster presentation at SMART NJ Symposium on Biotechnology and Center for Photonics and Opto-Electronic Materials (POEM) Annual Research, Princeton, NJ, October 2002.

Peter Tarsa, Paul Rabinowitz, Kevin Lehmann. "Cavity ringdown spectroscopy in a passive optical fiber resonator." Poster presentation at Greater New York Metropolitan Area 2003 Chemistry Graduate Student Poster Session, New York, NY, February 2003.

Peter Tarsa, Paul Rabinowitz, Kevin Lehmann. "Expanded Applications: Optical Fiber Resonator." Invited talk given at Tiger Optics, LLC Technical Review Board Meeting, May 2003.

P.B. Tarsa, P. Rabinowitz, K.K. Lehmann. "Optical Fiber Cavity Ring-down Spectroscopy" Poster presentation at 225th American Chemical Society National Meeting in both Physical Chemistry and Sci-Mix sessions, New York, NY, September 2003.

SKILLS

Scientific

Free space and fiber optics design and application in UV through mid-IR spectrum; laser installation, alignment, and maintenance; high vacuum techniques; chemical separation methods (HPLC, GC, and CE); spectral analysis techniques (UV/Vis, NIR, FT-IR, ^{1}H NMR, AA, Fluorescence spectroscopy); bacterial cell culture (*E. Coli*); mammalian cell biology techniques.

Interpersonal

Mentored two undergraduate and two graduate students in laboratory research and data analysis; personal tutor to high school chemistry and physics students.

Computer

Hardware: Computer design, construction, and laboratory interfacing; electronics design, repair and troubleshooting.

Software: MS Windows NT Server Administration, Mac OS administration, Blackboard Administration, MS Office, Adobe Photoshop, Jasc Paint Shop, Maple, Mathworks Matlab, Mathsoft Mathcad, Microcal Origin, Synergy Kaleidagraph

REFERENCES

Prof. Kevin K. Lehmann	Dr. Paul Rabinowitz	Prof. Matthew J. Lang
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